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ABSTRACT

The study was designed to test the hierarchy of difficulty in the acquisition of principles of class and conditional logic for 120 children of normal intelligence, and to compare the relative rates of logic development for those children of normal intelligence with the rate of logic development found in a previous study involving 120 gifted children (5 to 10 years old). Results of the Shigaki-Wolf logic test revealed that the difficulty hierarchy of normal Ss' class and conditional principles was similar to that of gifted Ss. Logic principles fell into three clusters: the easiest were affirming the antecedent, conclusion, and denying the consequent; intermediary were negative conclusion, minor premise, and class chain; and most difficult were linear and nonlinear transitivity, major premise, and conditional chain. Gifted Ss were at least 2 years accelerated over normal Ss. (Author/CL)

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NORMAL AND GIFTED CHILDREN'S CLASS AND CONDITIONAL LOGIC

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Abstract

These needs led to the study: (1) comprehensive exploration of both class and conditional logic, (2) utilization of subjects through the elementary years, and (3) comparisons between normal and gifted children. The difficulty hierarchy of normal children's class and conditional principles was similar to that of gifted children. Logic principles fell into three clusters: easiest were affirming the antecedent, conclusion, and denying the consequent; intermediary were negative conclusion, minor premise, and class chain; most difficult were linear and non-linear transitivity, major premise, and conditional chain. Gifted subjects were found to be at least two years accelerated over normals.

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The pioneering descriptive explorations into children's logic by such researchers as Hill (1961), Donaldson (1963), Ennis and Paulus (1965), Gardiner (1965), and O'Brien and Shapiro (1968) have opened up a fruitful area of investigation for the succeeding years. Despite the substantial body of knowledge which has been steadily accumulating since these early efforts, there are still several major gaps in the descriptive data base in the area. Three such gaps which this research endeavors to address are as follows: (1) There is a lack of systematic inquiry into a range of both class and conditional logic principles with the same sample. (2) Researchers have tended to focus on a restricted age span of child subjects rather than include the wider age span represented in the elementary schools. (3) Investigators have concentrated on subjects in the normal range of intelligence to the neglect of exploration of comparative abilities with precocious subjects who may show evidence of advanced mastery of logic principles even during

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the elementary years. The significance of each of these three areas of inquiry is developed below.

Range of Logic Principles

Research into children's logical abilities clearly documents the fact that elementary age children are able to comprehend some principles of logic. Much of this research, however, is characterized by a narrow focus on selected principles of either class or conditional logic. A library search yielded only a few studies with elementary age subjects exploring facets of both class and conditional logic (e.g., Ennis & Paulus, 1965; Roberge, 1970; Ryoti, 1972 and Sahin, 1975). In the first three studies cited above, however, subjects utilized were from grade four or age ten and older rather than tapping the full span of the elementary years. In the Ryoti study only fourth and ninth graders served as subjects. Subjects for the Ennis and Paulus study were students from age ten through age eighteen. Data on class reasoning were gathered only for 4th, 6th, 8th, 10th, and 12th graders, while data on conditional reasoning were gathered only for 5th 7th, 9th, and 11th graders. The study yielded a general pattern of development in logical thinking in adolescence, but strict comparisons cannot be made as neither the same subjects nor the same age groups were assessed using both class and conditional logic tests. The Roberge study included 4th, 6th, 8th, and 10th graders exploring their performance on six principles each of class and conditional reasoning. In the Sahin study on the other hand, children from ages four through thirteen served as subjects. Class and conditional valid forms and fallacies were explored.

In class logic the bulk of the studies have investigated a child's ability to recognize conclusions to valid syllogisms or to recognize when a syllogism is invalid (e.g., Hill, 1961; Shapiro & O'Brien, 1970; Roberge & Paulus, 1971; and Sahin, 1975). Yet logicians have long recognized that the

use of enthymemes with missing conclusions, missing minor premises and missing major premises are central to logical argumentation (see Shigaki & Wolf, 1980 for a more extended discussion of enthymemes). In the 1980 study by the present investigators five principles of class logic were explored involving the three orders of enthymemes. Findings for the gifted subjects of that study included statistically significant differences in the hierarchical ordering of the principles. Generating conclusions was the easiest, generating negative conclusions second easiest, generating minor premises and completing class chains were both third easiest, while generating major premises was the most difficult. Table 1 presents the five principles of class logic explored, their symbolic form, and a sample test item for each.

Insert Table 1 about here

Researchers have also been exploring a number of facets of conditional logic with school-age children. A cluster of conditional principles ordinarily studied together or in varying combinations include affirming the antecedent, denying the consequent, inversion-conversion fallacies, and conditional chains (e.g., Paulus, 1967; Roberge, 1970; Ennis, 1971; and Staudenmayer & Bourne, 1977). Transitivity has commonly been studied with subjects even as young as age four (e.g., Murray & Youniss, 1968; Riley & Trabasso, 1974; and Adams, 1978). In a companion study to the five principles of class logic with gifted students, the present investigators also explored five principles of conditional logic with the same gifted subjects (Wolf & Shigaki, 1978). Principles selected for study were affirming the antecedent, denying the consequent, conditional chain, linear transitivity, and non-linear transitivity, As in the study of class logic, fallacies were not investigated. Statistically significant differences among principles were found with both affirming the

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TABLE 1 (CONTINUED)

CLASS LOGIC PRINCIPLES WITH REPRESENTATIVE TEST ITEMS

	Principle	Symbolic Form	Sample Test Item
4.	Third-order enthymeme with particular negative minor premise (Missing negative conclusion)	All A's are B's. x is not a B. (x is not an A.)	All Mary's books are yellow. This book is not yellow. So? (What follows?) Ans: (This book is not Mary's.)
5.	Third-order enthymeme with two universal affirmative premises (Class chain)	All A's are B's. All C's are A's. (All C's are B's.)	All those who play in the park run fast. All the children in Mrs. Jones' class play in the park. What else is true? Ans: (All the children in Mrs. Jones' class run fast.)

antecedent and denying the consequent being easier than the remaining three principles, and linear transitivity and non-linear transitivity being easier than the conditional chains. In Table 2 the five principles of conditional logic are presented along with their symbolic form, and a test item for each.

Insert Table 2 about here

The present study proposed to extend the work done with gifted subjects to normal subjects of the same chronological age to determine whether the hierarchies of difficulty of the five class and five conditional principles are similar to that found for the gifted sample. Collection of this additional data would contribute toward a relatively comprehensive source of information allowing for comparisons between the gifted and normal samples. This study will differ from the Sahin study cited earlier, therefore, as different principles will be explored, particularly first and second-order enthymemes, and comparative data will be generated from two distinct populations.

Wide Age Span of Subjects

Researchers who have investigated the logical performance of children have usually confined themselves to subjects in the preschool and primary years, including subjects as young as three and four, (e.g., Hill, 1961; Murray & Youniss, 1968; Ennis, 1971; Riley & Trabasso, 1974; Kodroff & Roberge, 1975; Greenberg, Marvin, & Mussler, 1977; and Adams, 1978) or from the upper elementary grades (e.g., Ennis & Paulus, 1965; Neimark & Slotnick, 1970; Roberge & Paulus, 1971; and Staudenmayer & Bourne, 1977). Few studies were found which encompassed children from the primary grades to the upper elementary years. One reason for this is that instrumentation has posed a problem. Those researchers studying young children have often utilized a form of instrumentation including the manipulation of concrete objects, while those researching the abilities of older children favor a multiple choice format. In the few cases where investigators have utilized a wider age span of subjects, they have

TABLE 2

CONDITIONAL LOGIC PRINCIPLES WITH REPRESENTATIVE TEST ITEMS

Principle	Symbolic Form	Sample Test Item
1. Affirming the Antecedant	If p, then q p Therefore, q	If the dress is bright Jan will wear it Sunday. The dress is bright. So? Ans: (Jan will wear it Sunday).
2. Denying the Consequent	If p, then q Not q Therefore, not p	If the book is red, it belongs to Carl. It does not belong to Carl. So? Ans: (It is not red).
3. Linear Transitivity	A > B B > C So A > C	David is funnier than Mark. Mark is funnier than Jeff. What else is true? Ans: (David is funnier than Jeff).

TABLE 2 (CONTINUED)

CONDITIONAL LOGIC PRINCIPLES WITH REPRESENTATIVE TEST ITEMS

Principle	Symbolic Form	Sample Test Item
4. Non-Linear Transitivity	A < B A > C So B > C	Tom is shorter than Allan. Tom is taller than Peter. What else is true? Ans: (Allan is taller than Peter).
5. Conditional Chain	If p, then q If q, then r p, therefore, r	If Jim exercises, then he will be strong. If he is strong, then he will be healthy. What else is true? Ans: (If Jim exercises, then he will be healthy).

usually restricted themselves to an investigation of specific aspects of logic, usually those aspects where it was felt that responses could be obtained from even young children. For example, Shapiro and O'Brien (1970) examined the ability to recognize valid conclusions and the ability to differentiate them from statements where not enough clues were provided to determine the conclusion; Fitzgerald (1973) investigated performance on the logical concepts of conjunction and disjunction; and Emerson and Gekowski (1980) determined comprehension of sentences with "because" or "if." Though all three studies employed a wide age span of elementary school subjects, none investigated principles of both class and conditional logic. In contrast, the present study includes a range of children from ages five through ten, examining the development of various aspects of logic in children from the primary to the upper elementary years. The instrumentation developed and described in more detail below is such that it can be used effectively with this wide age span and includes principles of both class and conditional logic.

Comparison of Abilities of Gifted and Normal Children

As long ago as 1965 Ennis and Paulus identified the need for research in the development of logic with differing populations of children. Since that time there have been a number of studies, primarily doctoral dissertations, comparing performance in logic of middle-class and disadvantaged children or the performance of children of various ethnic backgrounds (e.g., Fitzgerald, 1973; Close, 1976; Mosley, 1978; and Worth, 1978). Curiously, little has been done comparing the logical abilities of children of varying intellectual abilities. A literature search uncovered a few dissertations examining the logical problem solving of intellectually-subnormal and normal children (e.g., Cherkes, 1973; Byrnes, 1977), but no study was discovered comparing gifted with normal children. One would assume that bright children would be accelerated in their mastery of logical principles. Determination of the extent of this acceleration would be of value to educators responsible for nurturing the talents of our future

leaders. Hence, a central contribution of the present study is to delineate developmental patterns of mastery of logical principles relative to gifted and normal samples.

Hypothesis and Research Question

The objectives of the present study are (1) to test the hierarchy of difficulty in the acquisition of principles of class and conditional logic for children of normal intelligence and (2) to compare the relative rates of logic development for those children of normal intelligence with the rate of logic development which was found for gifted children in a former study. Specifically, the following three hypotheses regarding the performance of normal subjects will be examined:

1. For class logic, the hierarchy of difficulty in supplying missing portions of syllogisms will be as follows: conclusions will be the easiest; negative conclusions will be the second easiest; class chains and minor premises will both be the third easiest; and major premises will be the most difficult.

   Rationale: This hierarchy of difficulty for class logic principles was found for the gifted sample. It is expected that the normal sample will produce a similar hierarchy of difficulty.

2. For conditional logic, the hierarchy of difficulty in supplying missing portions of syllogism will be as follows from the easiest to the most difficult: affirming the antecedent, denying the consequent, linear transitivity, non-linear transitivity, and conditional chains.

   Rationale: While significant differences were not found for the gifted sample between affirming the antecedent and denying the consequent or between linear and non-linear transitivity this was due in part to a ceiling effect for the first pair and a plateau effect for the latter pair of principles. With a normal sample, it is expected that the

differences within each pair will be more pronounced throughout the five to ten-year age span. The hierarchical ordering of the five principles is consistent, however, with that found for the gifted sample.

3. In comparing those principles which are isomorphic across class and conditional logic, affirming the antecedent will be easier than conclusions, denying the consequent will be easier than negative conclusions, and class chains will be easier than conditional chains.

Rationale: The differences hypothesized above are consistent with findings for the gifted sample.

Finally, the following research question will be explored relating data from the normal sample to that of the gifted sample. What is the extent of accelerated development of gifted children over normal children in the acquisition of principles in class and conditional logic?

Method

Sample

gathered and reported earlier (Wolf & Shigaki, 1978; Shigaki & Wolf, 1980) from a public school for the gifted in New York City with a mixed ethnic population were further analyzed for the comparative purposes of the present study. Data were utilized from twenty randomly-selected subjects at each age level from five through ten for a total of 120 gifted subjects.

Maintaining locality as a constant, the normal sample was selected from a public school in New York City where the majority of students were within the normal range of ability as indicated by available reading scores. Those children in the school who had been identified as intellectually gifted or as insufficiently fluent in English were excluded from the sample. Hence, students were randomly selected from the remaining student body and became a part of the sample when parental permission for participation in the study was received. The vast majority of parents contacted consented to have their child participate.

Twenty subjects were selected at each age level from five through ten for a total of 120 subjects in the normal sample. The combined gifted and normal samples made a total sample for the study of 240 children.

Performance scores on an intelligence measure provided further descriptive information concerning the two samples. All the children in the gifted sample had been tested with either the Stanford-Binet Intelligence Scale or the Wechsler Intelligence Scale for Children upon entrance into the school and had obtained a minimum score of 130. Since slightly different admissions criteria had been utilized by the school for each of the six age grouping, there was some variability in mean IQ scores across the age groups. Thus, the mean IQ for the total sample was 142.4 with a standard deviation of 9.4, while average IQ's varied among age groups in the gifted sample from 138.7 at age six to 149.0 at age five (see Table 3).

Insert Table 3 about here

Comparative intelligence quotients were not available for the sample from the normal population. Consequently, a rough intelligence index was determined by administering the vocabulary portion of the Stanford-Binet to each child after completion of the logic test. Given the age range of the total sample, it was necessary in some cases to use both the Picture Vocabulary and the Vocabulary Sub-test to identify basal age and ceiling. In contrast to the gifted sample, the mean IQ for the normal sample was 96.0 with a standard

TABLE 3

MEANS AND STANDARD DEVIATIONS FOR INTELLIGENCE

BY SAMPLE AND AGE

Age	Gifted		Normal	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
10	138.9	8.7	87.2	14.9
9	144.4	8.8	90.4	16.8
8	140.3	8.9	97.1	25.8
7	143.1	10.9	91.5	23.6
6	138.7	9.0	104.4	27.6
5	149.0	10.2	105.2	23.1
Total	142.4	9.4	96.0	22.0

deviation of 22.0, while average IQ's varied among age groups in the normal sample from 87.2 at age ten to 105.2 at age five. Means and standard deviations for each age group for the normal sample are also presented in Table 3.

Instrumentation

The Shigaki-Wolf logic test utilized for the present study consists of 33 items assessing five principles each of both class and conditional logic (see Tables 1 and 2 above for description of each of the principles.) Either three or four items were constructed to evaluate each of the ten principles of logic. A more detailed description of the instrument including validity information is available in Shigaki and Wolf (1980). Test-retest reliability of the instrument was re-established with a subgroup of the normal sample and re-computed together with a subgroup of gifted sample. Seven children each from age groups five, seven and nine were selected from the normal sample for a total of 21 children. Five children each from the same age groups were selected from the gifted sample for a total of 15 subjects. Data from the 21 normal and 15 gifted children were pooled to determine reliabilities for the composite sample. All 36 subjects were tested twice using the same protocal with one week intervening between testing sessions. A different tester administered the instrument for each session. Reliability coefficients for the normal subgroup of 21 were .90 on the class logic subtest, .90 on the conditional logic subtest, and .94 on the full scale. Reliability coefficients for the composite subgroup of 36 were .87 on the class logic subtest, .93 on the conditional logic subtest, and .94 on the full scale.

Procedure

A team of female testers was carefully trained to administer the test of logic. The same three team members tested the majority of the children in both the gifted and normal samples. Testing was conducted during the spring for the gifted sample and December of the same year for the normal sample. The data were collected through an individual oral session with each child in a room apart from the classroom. Each child's responses were recorded on the test protocols and simultaneously and unobtrusively tape recorded for the gifted sample. The precautionary measure of having a back-up tape recording was found to be unnecessary and was dispensed with during data collection with the normal sample. The first few minutes of each session were used to establish rapport, obtain background information on the child, and introduce the test with the sample item. Following the child's response to the sample item, he was told if his answer was correct or incorrect. In all cases the correct answer was read to the child. On the test proper, testers were instructed not to indicate to the child whether or not his response was correct, but to merely respond with a non-committal "O.K." before proceeding to the next item. For the normal sample the logic test was immediately followed by the Vocabulary Sub-Test from the Stanford-Binet. An informal exchange between tester and subject provided closure for the child. The length of the sessions for both samples was about the same, i.e., approximately 20 minutes. Counterbalancing to control for the effects of tester, room, and time of day was utilized across all age levels.

The test protocols for the gifted sample were scored first by two judges working independently. Agreement was obtained on the overwhelming majority of items. In the few cases of disagreement totalling far less than 1% of all items, the tape recordings were consulted and a mutual decision between the two judges concerning the correctness of these answers was reached. Correct and incorrect

responses for each item were catalogued and served as the guide for scoring the protocols for the normal sample. The same two judges were utilized to score the tests for the normal sample.

Results

To test the three hypotheses concerning the acquisition of selected principles of logic for the normal sample, a 6 X 10 factorial analysis of variance was computed with repeated measures on the last factor (6 levels of age, 10 principles of logic). Since there was an unequal number of items assessing each of the five principles of class logic, raw scores were converted to proportions which in turn were subjected to the arcsine transformation to insure a normal distribution. A .01 level of significance was utilized for all analyses. Significant F values were obtained for the main effects of age (F=27.293, df=5,114) and logic principles (F=112.356, df=9,1026). There was also a significant interaction effect between age and logic principles (F=7.163, df=45,1026).

The Tukey HSD test was utilized to determine where significant differences occur for the main effect of logic principle for the normal sample. Results of this analyses are tabulated in Table 4. As can be seen from this table, the hierarchical ordering predicted in hypothesis one for class logic principles was

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Insert Table 4 about here

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maintained, i.e., conclusions were the easiest; negative conclusions were the second easiest; class chains and minor premises were third easiest; and major premises were the most difficult. Unlike data from the gifted sample, however, differences between negative conclusions and both class chains and minor premises were not significant. Therefore, hypothesis one received only partial confirmation.

TABLE 4

TUKEY TEST FOR DIFFERENCES BETWEEN MEANS BY PRINCIPLE FOR THE NORMAL SAMPLE

(ARCSINE TRANSFORMED SCORES)

Principle	$\bar{X}$	C	DC	NC	Mi	Cl	LT	NT	Ma	Co
Affirming the Antecedent (AA)	1.626	.082	.155	.573*	.675*	.688*	.920*	.954*	1.022*	1.047*
Conclusion (C)	1.544	-	.073	.491*	.593*	.606*	.838*	.872*	.940*	.965*
Denying the Consequent (DC)	1.471		-	.418*	.520*	.533*	.765*	.799*	.867*	.892*
Negative Conclusion (NC)	1.053			-	.102	.115	.347*	.381*	.449*	.474*
Minor Premise (Mi)	.951				-	.013	.245*	.279*	.347*	.372*
Class Chain (Cl)	.938					-	.232*	.266*	.334*	.359*
Linear Transitivity (LT)	.706						-	.034	.102	.127
Non-Linear Transitivity (NT)	.672							-	.068	.093
Major Premise (Ma)	.604								-	.025
Conditional Chain (Co)	.579									-

*Significant at the .01 level

It was predicted in hypothesis two that for conditional logic principles the hierarchy of difficulty from easiest to most difficult would be as follows: affirming the antecedent, denying the consequent, linear transitivity, non-linear transitivity, and conditional chains. While this hierarchical ordering was obtained for the normal sample, significant differences were not found between affirming the antecedent and denying the consequent or between linear and non-linear transitivity. These findings are consistent with the results from the gifted sample. However, unlike the data from the gifted sample, there were no significant differences between conditional chains and either linear transitivity or non-linear transitivity. All other differences were significant (see Table 4). Hence, hypothesis two also received only partial confirmation.

Finally, in hypothesis three comparisons between similar principles of both class and conditional logic were made. As predicted, denying the consequent was significantly easier than negative conclusions while class chain was significantly easier than conditional chains. Unlike data from the gifted sample there was no significant difference between affirming the antecedent and conclusions (see Table 4).

Ancillary analyses included the Tukey HSD test for the main effect of age and Tukey test for interaction effects to determine the source of the age x principle interaction. The results for the main effect of age revealed that as might be expected older children (8, 9, and 10) generally performed significantly better than younger children (ages 5, 6, and 7). The only exception to this overall pattern was that the six's performed slightly better than the seven's, which accounted for the lack of significant difference between six's and eight's. The interaction effect was attributable to the reversal of mastery for the normal sample at ages six and seven, and again at ages nine and ten.

To answer the research question concerning the extent of accelerated development of gifted children over normal children in the acquisition of the

logic principles a 2 x 6 factorial analysis of variance was computed using total raw scores (2 samples, 6 levels of age). Significant differences were obtained for the two main effects of sample (F=268.444, df=1,228) and age (F=40.837, df=5,228). The Tukey test was utilized to determine the pattern of acceleration of the gifted sample over the normal sample by age. These data are tabulated in Table 5. The five's and six's of the gifted

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Insert Table 5 about here

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sample were significantly better than the five's, six's and seven's from the normal sample. At age seven the gifted sample was significantly better than all age groups except age nine from the normal sample. By ages eight, nine, and ten the gifted sample performed significantly better than all the age groups from the normal sample. Hence the performance of the gifted sample was generally accelerated over that of the normal sample by a minimum of two years.

Discussion

Patterns of mastery of ten logic principles by the normal sample were found in the present study to closely approximate that of the gifted sample reported earlier (Wolf & Shigaki, 1978; Shigaki and Wolf, 1980). For the normal sample, the ten principles of logic cluster into three distinct groupings according to difficulty. The three easiest principles are affirming the antecedent, conclusion, and denying the consequent with the differences among these three being non-significant. The second grouping includes negative conclusion, minor premise, and class chain; again there were no significant differences among them. Significant differences were found, however, between all three principles in the first cluster and all three principles in the second cluster (see Table 4). The third cluster consists of four principles:

TABLE 5

TUKEY TEST FOR DIFFERENCES BETWEEN MEANS OF TOTAL SCORES BY AGE

(GIFTED SAMPLE MINUS NORMAL SAMPLE)

Gifted Sample Age	Normal Sample 5	6	7	8	9	10
5	9.35*	5.15*	5.65*	0.90	-2.70	-1.60
6	12.30*	8.10*	8.60*	3.85	0.25	1.35
7	16.20*	12.00*	12.50*	7.75*	4.15	5.25*
8	17.55*	13.35*	13.85*	9.10*	5.50*	6.60*
9	21.15*	16.95*	17.45*	12.70*	9.10*	10.20*
10	20.45*	16.25*	16.75*	12.00*	8.40*	9.50*

*Significant at the .01 level

linear transitivity, non-linear transitivity, major premise, and conditional chain. Again there were no significant differences among the four principles, but all four principles in the third cluster were significantly more difficult than all of the principles in the first and second clusters. For the gifted data on the other hand, while the same three clusters can be identified there was greater variability of responses. Specifically, in the second cluster negative conclusion was significantly easier than both minor premise and class chain (Shigaki & Wolf, 1980), and in the third cluster the conditional chain was significantly more difficult than both linear and non-linear transitivity (Wolf & Shigaki, 1978). These differences can be discerned by an examination of Table 6 which presents the proportion correct for each of the ten logic principles by age and sample. For example, in the third cluster the gifted sample varied from 26.4% correct for linear transitivity to 11.4% correct for conditional chains; while responses from the normal sample were uniformly low: linear transitivity 6.7%, non-linear transitivity 5.0%, major premise 5.0%, and conditional chain 0.3%. This reflects, of course, the relative difficulty of the principles in the

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Insert Table 6 about here

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third cluster for the normal sample. For example, not until age ten did any subject from the normal sample responded appropriately to a conditional chain, while some gifted subjects as young as age five responded correctly.

A consistent pattern concerning the relative difficulty of class and conditional principles did not emerge. It would appear instead that the ten principles of logic explored in the present study might be grouped by level of difficulty for instructional purposes rather than assuming as have many disciples of Piaget that mastery of class logic precedes that of conditional logic.

Concerning the pattern of acquisition of the logic principles, as was expected,

TABLE 6

PROPORTION CORRECT BY SAMPLE, AGE, AND LOGIC PRINCIPLE

Age	Affirming the Antecedent		Conclusion		Denying the Consequent		Negative Conclusion		Class Chain		Minor Premise		Linear Transitivity		Non-Linear Transitivity		Major Premise		Conditional Chain		Total	
	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal	Gifted	Normal
10	95.0	83.4	98.7	78.8	96.7	75.0	86.7	35.0	81.7	33.4	72.5	28.8	43.3	5.0	36.7	8.4	23.7	10.0	15.0	1.7	65.0	36.0
9	95.0	81.7	100.0	76.3	100.0	85.0	93.3	46.7	78.3	33.4	66.2	36.3	51.7	16.7	33.3	16.7	32.5	3.8	21.7	0.0	67.2	39.7
8	93.3	68.4	92.5	58.8	91.7	53.4	80.0	25.0	65.0	31.7	53.7	23.8	33.3	15.0	21.7	3.4	21.2	6.3	10.0	0.0	56.2	28.6
7	98.3	35.0	88.7	38.8	90.0	21.7	76.7	16.7	48.3	5.0	52.5	16.3	20.0	0.0	16.7	0.0	18.8	3.8	10.0	0.0	52.0	13.7
6	85.0	38.4	85.0	35.0	78.3	30.0	40.0	18.4	40.0	6.7	43.8	15.0	5.0	3.4	3.3	1.7	7.5	6.3	10.0	0.0	39.8	15.5
5	73.3	8.4	63.7	5.0	56.7	6.7	41.7	3.4	23.3	0.0	32.5	6.3	5.0	0.0	5.0	0.0	7.5	0.0	1.7	0.0	31.0	3.0
Total	90.0	52.5	88.1	48.8	85.6	45.3	69.7	24.2	56.1	18.4	53.5	21.1	26.4	6.7	19.5	5.0	18.5	5.0	11.4	0.3	51.9	22.8

gains were incremental by age except for two reversals at ages six and seven and again at ages nine and ten for the normal sample. These reversals may be accounted for in part by the discrepancy in measured intelligence since the average IQ at age six was almost a standard deviation higher than the average IQ at age seven. While the difference in IQ between the nine's and ten's was not as great, the younger group scored on the average 3.2 IQ points higher than the older group (see Table 3). Further contributing to the reversal in performance between nine's and ten's is the levelling-off of performance at these ages which is consistent with that reported earlier (Shigaki & Wolf, 1980). This plateau effect warrants further investigation particularly with an extended upper age range sample.

In general it was found that the gifted sample was at least two years accelerated over the normal sample in their ability to generate missing portions of both class and conditional syllogisms though the extent of acceleration varied from principle to principle. Thus in the gifted sample, already by age five well over 50% of the syllogisms were completed correctly in the easiest cluster consisting of affirming the antecedent, conclusion, and denying the consequent. A comparable percentage of correct responses was not attained by the normal sample until age eight. By age eight those in the gifted sample were able to respond appropriately to at least 50% of the syllogisms in the second cluster consisting of negative conclusion, class chain, and minor premise. Even by age ten a comparable rate of mastery was not obtained by the normal sample, with mastery remaining at approximately the 33% level. As reported above, mastery of the four principles in the third cluster, i.e., linear transitivity, non-linear transitivity, major premise, and conditional chain remained extremely low for the normal sample through the age span. For the gifted sample, on the other hand, mastery of linear transitivity reached the 50% mark by the nine's with mastery of

non-linear transitivity and major premises ranging from 23.7% to 36.7% for the nine's and ten's. Conditional chains remained the most difficult of this cluster of all ten principles with 21.7% correct by the nine's and 15% correct by the ten's of the gifted sample (see Table 6).

Given the existing body of research regarding the logic abilities of young children, clearly there is now persuasive evidence that a substantial proportion of children even in the early elementary years can respond appropriately to some principles of class and conditional logic. To build on this knowledge, further research is needed in two key areas: curriculum construction and theory formulation. Contributions to the development of a logic curriculum such as by Wolf, Huck, and King (1967); Simcox (1970); and Lipman, Sharp, and Oscanyan (1980) need to be extended with appropriate articulation between curriculum development and the existing descriptive research data. This would include the nurturance of logic which is developmentally appropriate to the child with a recognition of both normal development and the accelerated development of more precocious children. Concurrently, there is a need to investigate the process involved in logical thinking (e.g., Sternberg, 1980) leading to theory formulation and testing.

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